Talk 1: "Modular and Robust Localization" (Christian Brommer, M.Eng.)

Autonomous aerial or ground vehicles are of the ever-growing interest in industry and academic research. Fully autonomous vehicles require robust control and state-estimation, that is, accurate knowledge of the location and orientation of the vehicle with respect to the world. Whereas in theory and simulation, signals behave 'as expected' in which the noise distribution of sensor signals are perfectly Gaussian distributed, and the calibration of sensors are non-varying and exactly known - this does not apply for real-world applications. To incorporate runtime and long-term self-calibration of sensor states and active failure detection in a statistically sound fashion is yet another essential aspect for the robust localization of a robot. Long-term self-calibration is especially impotant for remote vehicle, such as the Mars helicopter, which can not be accessed for re-calibration once they have been deployed.

This talk will focus on three aspects with respect to the development of robust robot localization methods. The first aspect will address the usage of magnetometer signals for attitude determination in distorted magnetic fields. This will show the importance on choosing the correct signal representation, measurement model design, and dynamic adaptation of a filter to environmental changes.

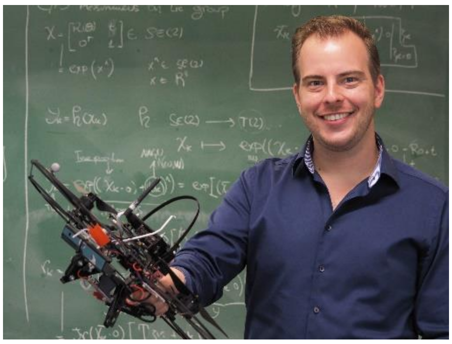
The second aspect of the talk will present a modular and robust state-state estimation framework (MaRS), which we will open-source. This aspect will show the importance of efficient computation for systems with a high number of calibration states and dynamic sensor on- and off-boarding. This is especially important for applications with computationally constraint platforms. We will give a short introduction to this framework and its usage from a high-level perspective such that researchers without in-depth knowledge in state estimation can use this framework as a tool for their research.

The third and concluding aspect will show a short outline of our multi-sensor, multi-environment dataset that provides sensor information and ground truth for cross-discipline state-estimation tasks, including VIO, online sensor switching, and real-world sensor degradation.

Christian Brommer
Control of Networked Systems Group
Universität Klagenfurt

UNIVERSITÄT KLAGENFURT

Christian Brommer is a Ph.D. student in the field of multi-sensor fusion and state estimation in the Control of Networked Systems Group at the University of Klagenfurt since June 2018. Before, he was an intern at JPL until May 2018 and studied at the University of Applied Science in Dortmund Information- and Electronics with a specialization in signal processing. He wrote his Master's-Thesis about "Development of a Tandem Micro Air Vehicle System for Joint 3D Terrain Reconstruction" at JPL. He is also the Co-I/task manager for the ongoing AMADEE/AMAZE project as part of a simulated Mars mission in Israel, planned for the end of 2021. Christian's skills include sensor fusion, robotics hardware, UAV operation, and software programming.



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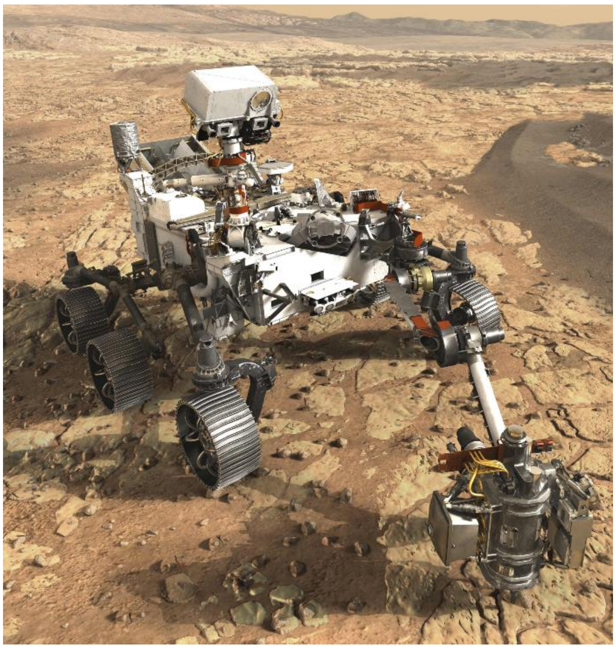
Talk 2: "Eyes on Mars: What robots see on the red planet" (Dr. Roland Brockers)



Cameras are an essential component of almost every unmanned space craft we ever launched for space exploration. Since an image can tell more than a thousand words, we are stunned by images from space-born telescopes, planetary orbiters, or robotic explorers that are send to capture the unknown. Vision provides such a rich source of information, that various missions have taken advantage of computer vision methods in the past. This is especially true for Mars where a multitude of robotic explorers have been deployed – in space, on the ground, and recently: in air ! While image data from orbiters is used to map the surface of almost the entire planet to plan for future surface missions, Mars landers have used vision for safe landing and robotic surface vehicles like the Mars Rovers rely on vision during autonomous operation.

In this talk, we will explore how computer vision has been used by various Mars missions. We will look over the shoulder of Mars rovers to learn how they perceive their environment during autonomous driving and introduce our newest member of Mars robotic vehicles: the Mars Helicopter *Ingenuity* that travelled to the red planet as part of the Mars 2020 mission. *Image credits: NASA/JPL – Caltech.*

Propulsion Laboratory
Mobility and Robotic Systems Section
California Institute of Technology

JPL NASA
Jet Propulsion Laboratory
California Institute of Technology

Roland Brockers is a Research Technologist at NASA's Jet Propulsion Laboratory/California Institute of Technology with more than 20 years of R&TD experience in vision-based autonomous navigation of unmanned systems. He received his Ph.D. in Electrical Engineering from the University of Paderborn, Germany, in 2005. He was part of the Mars Helicopter *Ingenuity* Guidance Navigation and Control (GNC) team and wrote the image-processing software that *Ingenuity* will uses for navigation. He has been principal investigator/task manager on numerous JPL micro air vehicle related tasks for the last 9 years, including a current project that is looking into advanced navigation methods for a future Mars Science Helicopter concept.

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